Geographical overview of Mars

Abstract: Extending living creatures on Earth from 4.0 billion year ago to till our present day lived and diversified under a specific physical & environmental condition of Earth, where Earth's gravity playsan important role. But populations of this planet are growing at a rapid speed; to the point where it becomes concerning that the Carrying Capacity of Earth has been overcome. So, for maintaining the Carrying Capacity, it is important to find out another planet alike Earth. In present day some genius believes that Mars (Red planet) environment is possible to create an ecosystem for human surviving. Although there seems to be no life on present Mars, even there is substantial evidence, returned by various robotic mission, that in the early Mars' history, liquid water environments existed, and conditions may have been suitable for the origin of native life.

Key words: NASA, Atmosphere, Earth, Genesis of Life,Mars,Regolith.

Introduction

In our Solar System, the fourth planet from the Sun, Mars, also called Red planet due to presence of reddish iron-oxide on its surface is a dusty, cold, dry, desert world with an ultra-thin atmosphere. Atmospheric dynamic of Mars and Earth are similar. The rotational period and seasonal cycles of Mars likewise similar to those of Earth. Approximately half in diameter of Earth, Mars have about 15% of Earth's volume, 11% of Earth's mass, 38% of Earth's surface gravity (Table 1), without plate tectonicsand global oceans. The present-day tilt of Mars axis (25.2°) is alike to that of Earth (23.5°), whereasOrbitaleccentricity of Mars (0.09) is much larger than Earth's (0.015).Orbits elements of Mars exhibit Milankovitch cycle, alike Earth at period varying from 50,000 to several million years, that greatly affects how much sunlight reach the surface, which modify Mars climate.

TABLE 1

Comparison between Earth and Mars orbital parameters:

Property	**Earth**	**Mars**
Mass (kg)	$5.972\ 37\times10^{24}$	6.4171×10^{23}
Volume (km)	$1.083\ 21\times10^{12}$	1.6318×10^{11}
Axial tilt (°)	23.439 2811	25.19
Orbital eccentricity	0.015	0.09
Mean density (g/cm³)	5.514	3.9335

Surface gravity (m/s²)	9.807	3.720 76
Average orbital speed	29.78	24.007
Radius (m)	6 369	3 394
Length of solar day (s)	86 400	88 775
Spin-axis inclination (°)	23.5	25.2

Aim & Objective

The objective of current paper is to give general physical environmental information about Mars.

Data base & methodology

The data used in this presented paper is secondary data collected from different websites, and articles. For the present study, the important tables were created by using Microsoft word.

Scientific investigation on Mars: To investigate Mars,NASA's Mariner 4, was the first successful flyby, carried by Atlas LV-3 Agena-DRocket, that return the first close-up images of the Red Planet, and within 25 minutes it took 21 full pictures of this planet. AfterMariner 4, NASA's Mariner 6, Mariner 7 (1969), are the dual successful mission to Mars that's goals were to study the surface and atmosphere of Mars. The first spacecraft to orbit of another planet, NASA's Mariner 9 reached the red planet orbit on 14 November 1971, was designed to continue atmospheric studies started by Mariner 6 and 7. Mariner 9 returned 7329 images, revealed river beds, craters, extinct volcanoes, canons, Valles Mariners. Mariner 9 ends its investigation on 27 October, 1972. Its cameras were the first to capture the gamut of Martian geology. Martian Moons (Phobos and Deimos) are also captured by Mariner 9's camera. NASA's robotic spacecraft, 2001 Mars Odyssey, reached Mars orbit on 25 October 2001. About 85% images captured by *Spirit*, and *Opportunity*have reached Earth via Mars Odyssey orbiter. To map the Martian landscape, NASA's Mars Reconnaissance Orbiter inserted on Mars orbit on 10 march,2006 and it play an important role in selecting the landing site of Phoenix lander. To determine how the atmosphere and water were lost over time, NASA's MAVEN (Mars Atmosphere and Volatile Evolution), inserted in Mars orbit on 22 September 2014. A global mapping mission for Mars, NASA's Mars Global Surveyor inserted in Mars orbit in 12 September 1997 continued its mission up to 2 November, 2006.India's first Mars mission "Mars Orbiter Mission", (*Mangalyaan*)reach Mars Orbit to investigate atmosphere, surface feature, morphology, mineralogy.Exo-Mars Trace Gas Orbiter reached on Mars orbit on 19 October, 2016, that's goal was to investigate the methane and other trace gases in atmosphere. Two successful gravity assister used in Marsinvestigation areRosetta andDawn. NASA'S Viking (Viking 1, Viking 2) mission objectives were to capture images of Martian surface, and examine the atmosphere and surface of Mars. Viking 1 enter Mars orbit on 19 June, 1976 whereas Viking 2 on 7August, 1976. Orbiter images of Viking mission revealed volcanoes, lava plains, canyons, cratered areas, and evidences of surface water.

Out of all successful Mars mission Landers and rovers are tabulated below:

Spacecraft	Landing site	Time period
Lander:		
1. Viking 1	Chryseplanitia	20.7.1976 - 13.11.1982
2. Viking 2	Utopia Planitia	3.9.1976 - 11.4.1980
3. Mars pathfinder	Oxiapalus quadrangle Ares Vallis,Chryseplanitia	4.7.1997 - 27.9.1997
4. Phoenix	Vastitas Borealis, Green valley	25.5.2008 - 2.11.2008
5. Insight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport)	Elysium Planitia	26.11.2018 - present
Rover:		
1. Sojourner	Area Vallis region	4.7.1997 - 27.9.1997
2. Spirit	Gusevcater	4.1.2004 -22.3.2010
3. Opportunity	Bowl crater within the MeridianiPlanum region later nicknamed ‘‘Eagle Crater’’	24.1.2004- 10.6.2018
4. *Curiosity*	Yellowknife of Aeolis Palus, located between Gale crater and the northern foothills of Aeolis Mons	6.8.2012 –present

Physical Environment of Mars.

1. Surface topography

The terrestrial plant,Mars having surface area of about 144.8 million km², that is about 28% of Earth (510.1 million km²), dotted with impact craters alike Moon, and contain Basin, Valles, extinct Volcanoes like that of Earth. ThisMartian surface features have been divided into three age groups—Noachian, Hesperian, and Amazonian—on the basis of intersection relations and the numbers of superimposed impact craters (Scott and Carr, 1978; Tanaka, 1986).Early time period of Red planet, Noachian terrains survive from the early heavy bombardment era. This era was named for the heavily cratered Noachis region and Noachian era ended around 3.7 Gyr ago. Middle Hesperian period started by the end of late heavy bombardment, named after Hesperia Planum (a broad lava plain, located along the broad north-eastern rim of the giant Hellas impact basin), characterised by expansive volcanic activity. Hesperian era ended around 2.9–3.3 Gyr ago. Present day continues most modern period of Mars, Amazonian (~0-3 Ga), named after AmazonisPlanitia (24.8°N, 196.0°E) sometime subdivided into Early, Middle, Late Amazonian period, characterised by low rates

of meteorite and asteroid impacts. Most of largest topographic features are formed during or before Noachian periods. Within all Martian topographic features the most important large scale features are the Tharsis bulge, the Hellas impact crater, the Argyre impact crater, and the north-south dichotomy.

Impact craters: Largest visible impact crater in our Solar System, the impact basin Hellas (42.4°S 70.5°E), was the first Martian features discovered from Earth by using Telescope, having 7,152 m deep and 2300 km diameter. Victoria crater (2.05°S, 5.50°W) in Meridianiplanum was first identified by Opportunity (Table 2). Opportunity (MER-B), after landing at Meridianiplanum (0.2°N 357.5°E) identified numerous cratersis listed below:

TABLE 2

Craters visited by MER-B:

Crater	**Location (Coordinates)**
Ada	3.0°S, 3.2°W
Airy	5.1°S, 0.1°E
Argo	1.9°S, 354.5°E
Beagle	2.0°S, 5.5°W
Beer	14.6°S, 8.2°W
Bopolu	2.95°S, 6.33°W
Crommelin	5.1°N, 10.2°W
Eagle	1.95°S, 354.47°E
Emma Dean	2.0°S, 5.5°W
Endeavour	2.28°S, 5.23°W
Endurance	1.9°S, 5.5°W
Erebus	2.1°S, 5.5°W
Firsoff	2.66°N, 9.42°W
Iazu	2.69°S, 5.2°W
Madler	10.8°S, 357.3°W
Santa Maria	2.172°S, 5.445°W
Victoria	2.05°S, 5.5°W
Vostok	1.9°S, 35.5°E

Basin: The Borealis Basin (North Polar Basin), located in the northern hemisphere of Mars covers 40% of the planet. Within Borealis Basin, Utopia Planitia (46.7°N, 117.5°E), Arcadia Planitia (47.2°N, 184.3°E), AcidaliaPlanitia (49.76°N, 339.3°E), Vastitas Borealis (87.73°N, 32.53°E), PlanumBoreum (88.0°N, 15.0°E) are also located. A plain, Helllasplanitia, located within the impact basin Hellas (42.4°S, 70.5°E, Hellas quadrangle). This basin floor is 7152 m deep, 3000 m deeper than Moon's South Pole-Aitken (largest known impact crater in the solar system) is about 13 km deep.

Valles: Valles Marineris (4,000 km long, 200 km wide and up to 7 km deep) the largest canyons of the Solar System, discovered by Mariner 9 runs along the Martian surface

east of the Tharsis region.Mangala Valles, is a criss-crossing channel on Tharsis region of Mars, that extends 350 km along the 151° W. meridian, from approximately 9° S to 4° S., but the main channel constitutes only 180 km of this distance.Mariner 9 orbiter (1971-1972),by discovering a great variety of channels and channel-like features on the Martian surface,provide a basis of Martian evolutionary history.

TABLE 3

Channels visualized by Mariner 9:

Channel	**Location(Coordinates)**
Ares Channel	Chryse, 0°-13°N., 15°-25°W
Ceraunius Dome Channel	Ceraunlus, 24°N., 89°W
Dendritic Tributary Channels	Tithonlus, 8°S., 84°W
Deuteronilus Channel	40°N., 338° W
Kasei Channel	LunaePalus, 20°-27°N., 55°-75°W
Ma'adim Channel	Rasena, 16°-29°S., 181°-184°W
Nirgal Channel	Mare Erythraeum, 29°S., 40°W
Shalbatana Channel	1.5°-8°N., 42°-45°W
Xanthe Channel	0°-8°N., 48°W

Volcanoes: One of the largest volcanoes in the Solar System, Alba Patera (40.5°N, 250°E), lying on the northern margin of Tharsis,covering more than 4.4 × 106 km² that is about one-third the height of Olympus Mons (18.65°N, 226.2°E), the largest and most prominent volcano on the planet Mars. Alba Patera has an overall basal width of 1015×1150 km and a summit elevation of 6.8 km. Vast volcanic plateau Tharsis, extends from AmazonisPlanitia (215°E) in the west to ChrysePlanitia (300°E) in the eastcovers up to 25% of Mars' surface area. Arsia Mons, Pavonis Mons, and Ascraeus Mons, three shield volcanoesare located in this Tharsis region, are jointly known as the Tharsis Montes. Ascraeus Mons is the tallest (18.2 km) of the Tharsis Montes. Tharsis Montes, and Olympus Mons in together, represent the most remarkable volcanoes on Mars. Beside these larger volcanoes,a wide variety of smaller volcanoesand volcanic features arerecognized on Mars.

TABLE4

Recognized Volcanoes on Mars

Alba Patera	JovisTholus
AlborTholus	Olympus Mons
AmphitritesPatera	Pavonis Mons
ApollinarisPatera	PeneusPatera
Arsia Mons	Syrtis Major MereoPatera
Ascraeus Mons	Syrtis Major NiliPatera
BiblisPatera	TharsisTholus
CerauniusTholus	TyrrhenaPatera
Elysium Mons	Ulysses Patera

HadriacaPatera	UraniusPatera
HecatesTholus	UraniusTholus

2. **Soil:**In general,soil is a mixture of organic matter, minerals, gases, liquids, and organisms anddue to such features, Earth is biologically active, Genesis of life. Key components of soils are mineral, organic matter, water, air. Martian soil features differ from Earth's soil due to presence of perchlorates, a toxic substance. Martian soil characteristically refers to the finer fraction of regolith, that is a geologic unit comprises dust, sand, rocky fragments.Olivine and pyroxene are two important classes of rock-forming minerals, also found by Curiosity rover on Mars crust.

   "In places this covering is made up of material originating through rock-weathering or plant growth in situ. In other instances, it is of fragmental and more or less decomposed matter drifted by wind, water or ice from other sources. This entire mantle of unconsolidated material, whatever its nature or origin, it is proposed to call the regolith." _George P. Merrill, American geologist.

Rover Sojourner was the firstthat detect the elemental chlorine on Martian soil. Presence of perchlorate also has been detected by Mars Odyssey orbiter. NASA's spirit rover find-out wide evidence of carbonate and hematite, associated with water environment. Phoenix lander was the first that detect the chlorine-based (0.5%) compounds on Martian soil. These chlorine-based compounds are toxic to plants as well as humans. Martian surface is sulphur-rich and sulphates are abundant on Hesperian and Noachian terrain,searchingof Mars Pathfinder and Viking landers revealed that sulphur is a substantial component of soil dust and surface rock.

3. **Atmosphere:**

In the mid-1970s,Viking landersdetermined thecomposition of Martianatmosphere.Ultra-thin atmosphere of Red planet is dominated mainly by carbon dioxide (95.97%), whereas Earth's atmosphere is dominated by nitrogen (78.08%) (Table 5). In addition to the carbon-dioxide the atmosphere also contains trace amount of water vapour (0.1%), nitrogen, trace amount of free oxygen. Trace amount of noble gases, neon, argon, krypton, xenon, are also identified. Methane (CH_4) also detected recently in trace amount. Unlike Earth's atmosphere due to absence of ozone layer, ultraviolet rays openly penetrate the atmosphere, and reach the surface. Mars does not bear stratosphere due to absence of ozone layer. According to Viking lander and Pathfinder lander the troposphere extends up to ~60 km (12 km, Earth), with average lapse rate of about ~2.5 K/km (~6.5 K/km, Earth).As reddish iron oxide prevalent on Mars surface, the atmosphere is quite dusty and orange red in colour. Average atmospheric pressure of Martian surface is about 6.1 mbar that is about 0.6% of earth's mean sea level pressure of 1013 mbar. Detected atmospheric pressure value by Viking 1 was 0.69 kpa to 0.9 kpa. Estimated temperature range by Viking lander site, was -17°C to -107°C. The highest temperature estimated by the Viking Orbiter was 27°C. ObservedtemperaturebyNASA'sSpirit rover was 35°C (highest level), but commonly recorded temperature well below of 0°C.The average surface temperature on Mars is approximately -63°C with an average diurnal range of around 103°C to -5°C (Hiscox, 2000).

Dust storms would-be the common phenomenon of Mars world. According to size,Dust storms are categorised into devil storms, local storms, regional storms, planet-encircling storms (lasts for months and occur quasi-annually).

TABLE 5

Comparison between Earth and Mars atmosphere Constituent:

Constituent	Earth	Mars
Carbon-dioxide	0.0408%	95.97%
Oxygen	20.95%	0.146%
Nitrogen	78.08%	1.89%
Argon	0.934%	1.93%
Carbon-mono-oxide	0.000025%	0.0557%

4. **Water :**On the basis of geologic evidence returned by various rover and orbitermission it is often stated that there is sufficient evidence for water on Mars, but there has been no direct observation of liquid water, only ice, vapour, and geomorphologic traces of the action of past liquid water. Mars' North Polar Region is covered with CO_2 ice during winter, whereas the south cap is covered year-round by CO_2 frost.Evidence of past liquid water on the surface of Mars suggests that this world once had habitable conditions for origin of life. Mars Odyssey orbiter detected subsurface ice, in high latitudes location.

Concluding Remarks: In our Solar System beside Earth, the best-studied planet Mars is the high-priority target for human exploration programme. United States National Aeronautical and Space Administration (NASA)**,** Indian Space Research Organisation (ISRO), The European space agency (ESA),Soviet-union, conducted various mission to Mars, for investigation.From Mariner 4 (launch on November 28, 1964) until Insight lander Mars has been successfully observed by several Orbiters and Landers, four of them rovers. In future there are somemissions will be launched from 2020Rosalind Franklin rover conduct by Russian Roscosmos State Corporation and European Space Agency's that's planned landing site is OxiaPlanum (21 March 2021). NASA's mission Mars 2020 rover, planned landing site is Jezero crater. The Hoppe Mars mission constructed by United Arab Emirates that's planned lunched date is July 2020. Indian's second Mars mission is the *Mangalyaan* 2with a planned mission duration of 1 year, that's lunch date is 2022-2023.

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